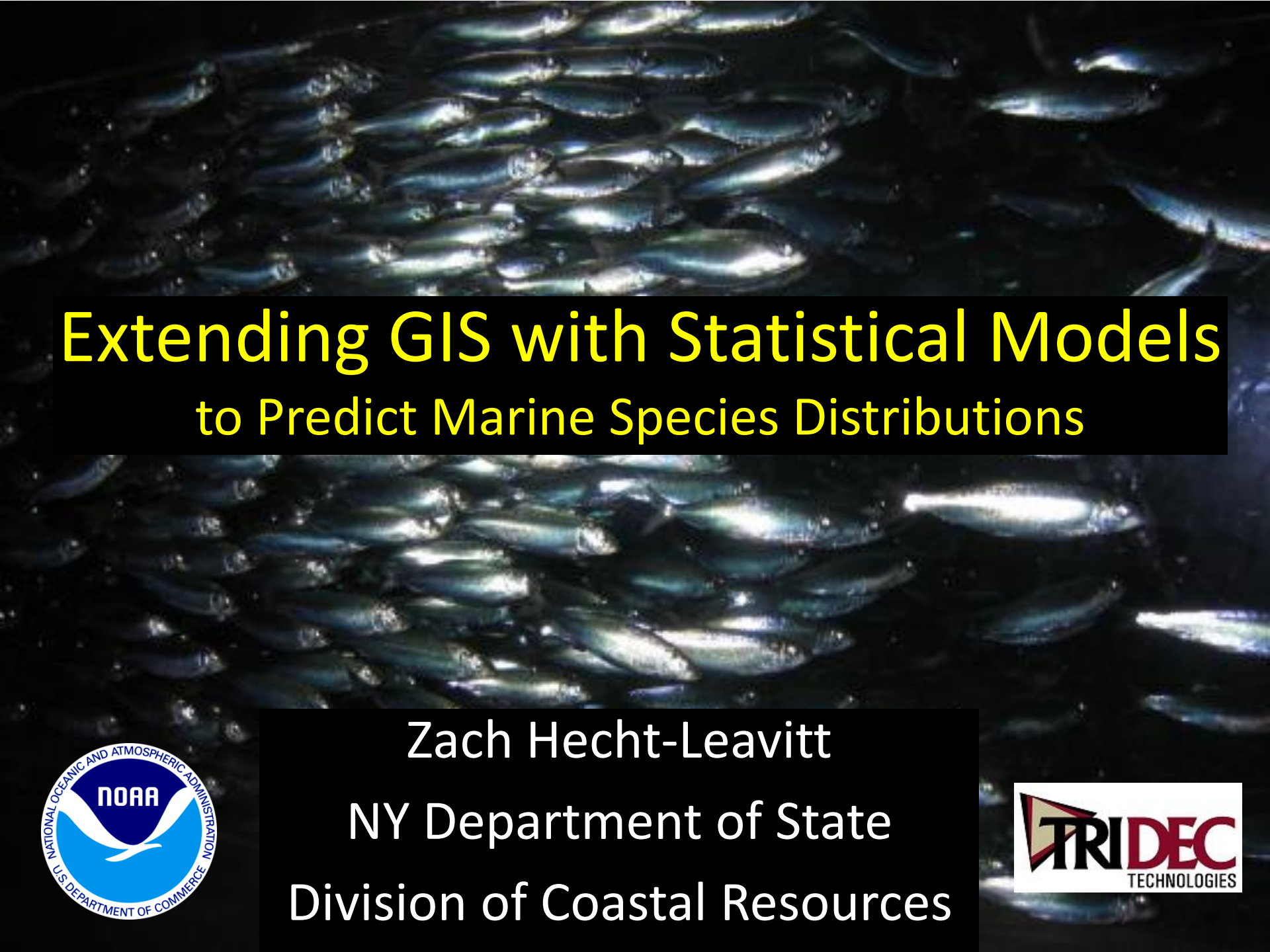


Extending GIS with Statistical Models

to Predict Marine Species Distributions

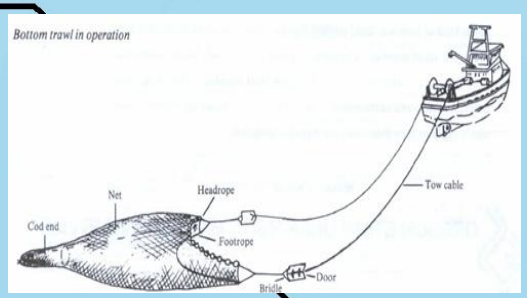
Zach Hecht-Leavitt

NY Department of State

Division of Coastal Resources

Offshore Planning

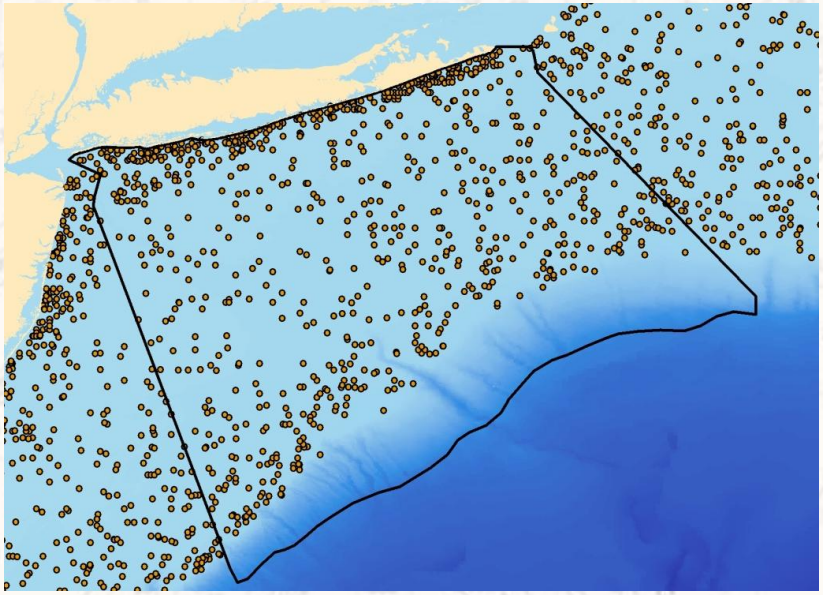
NY

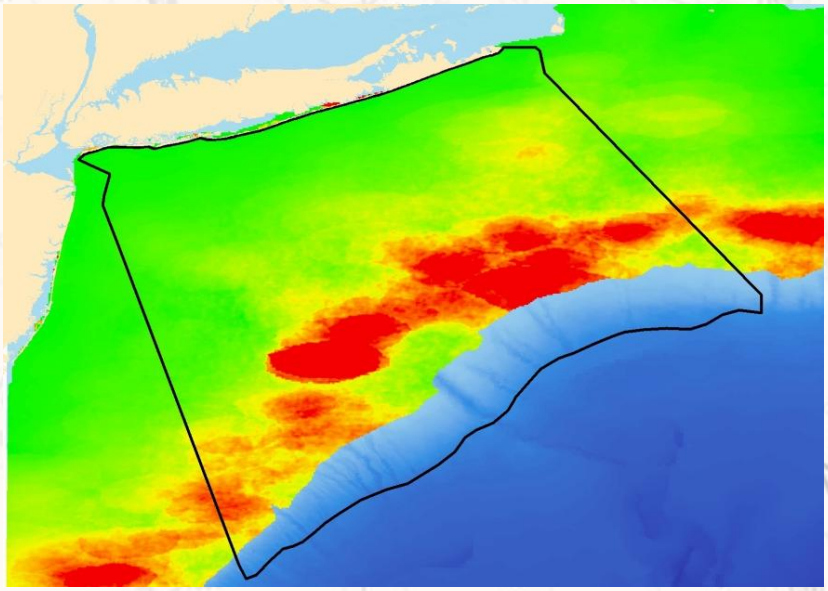


Goals

- **Predict the abundance** of selected groundfish species **as a function of**:
  - **environmental**/habitat variables
  - spatial **autocorrelation**
- Assess **error**
- **Understand** ecology

Goals



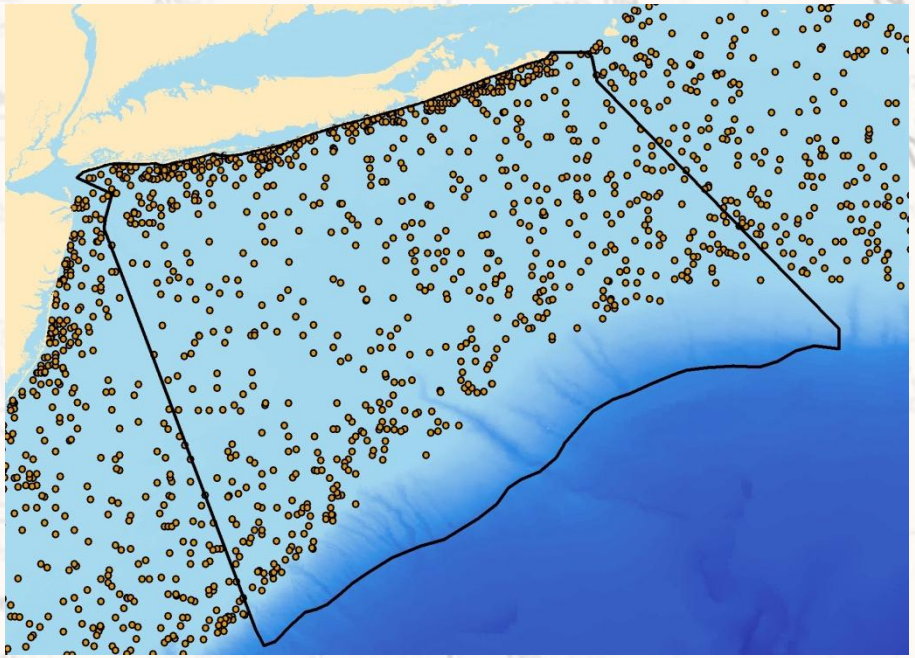


The Fish Data

- NOAA Northeast Fisheries Science Center bottom trawl (catches **groundfish**)
- Biannual 1975-2009
- **Standardized** gear, speed, and distance
- Cleaned by Stone Environmental
- Break down by **season** and **life stage**
- 6 species selected

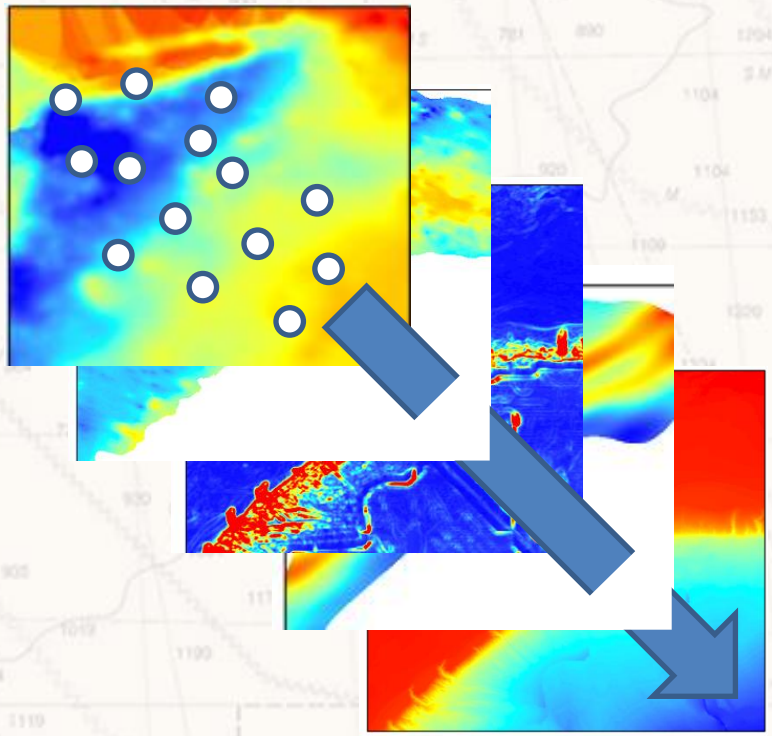

NOAA NEFSC

NOAA NEFSC



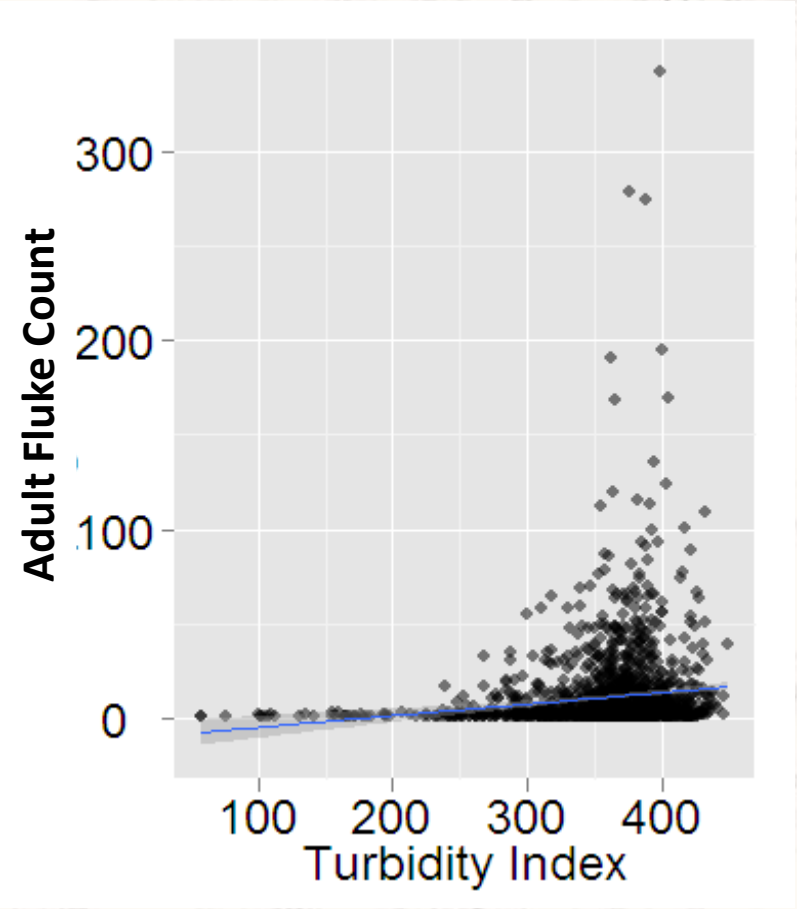
The Environmental Data

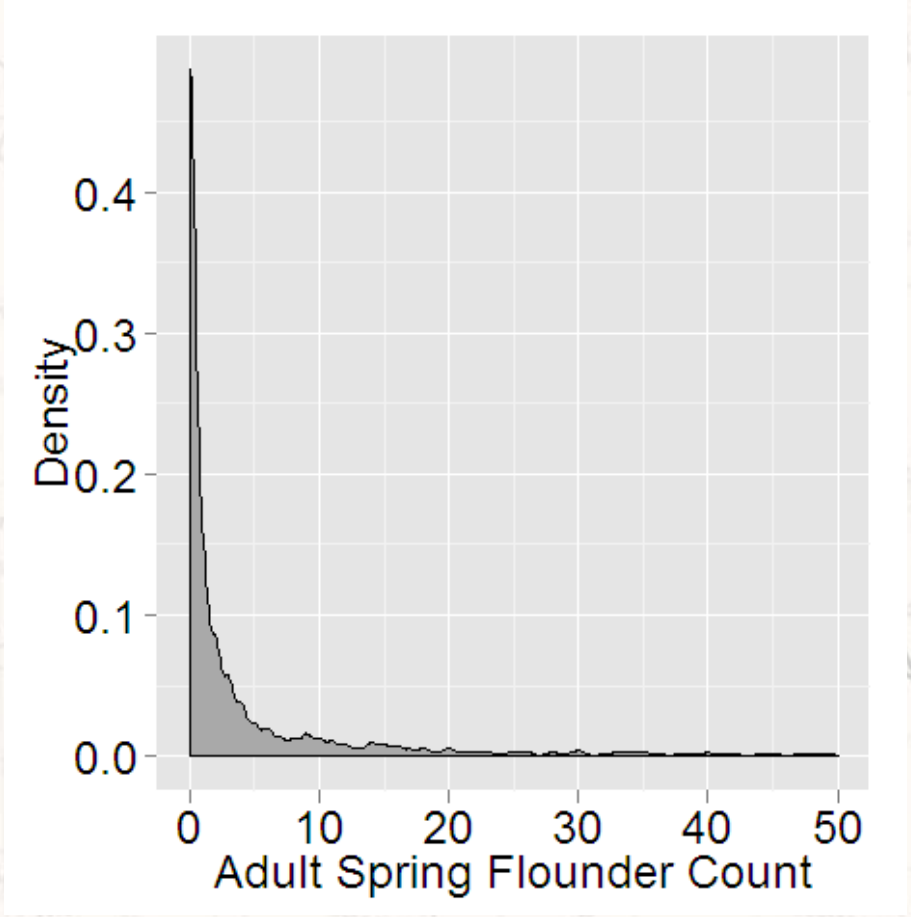
- Depth
- Distance from Shelf Edge
- Bottom Grain Size
- Slope
- Sea Surface Temperature*
- Chlorophyll*
- Stratification*
- Turbidity*
- Zooplankton*
- Provided by NOAA Biogeography Branch



*Long-term, seasonal average

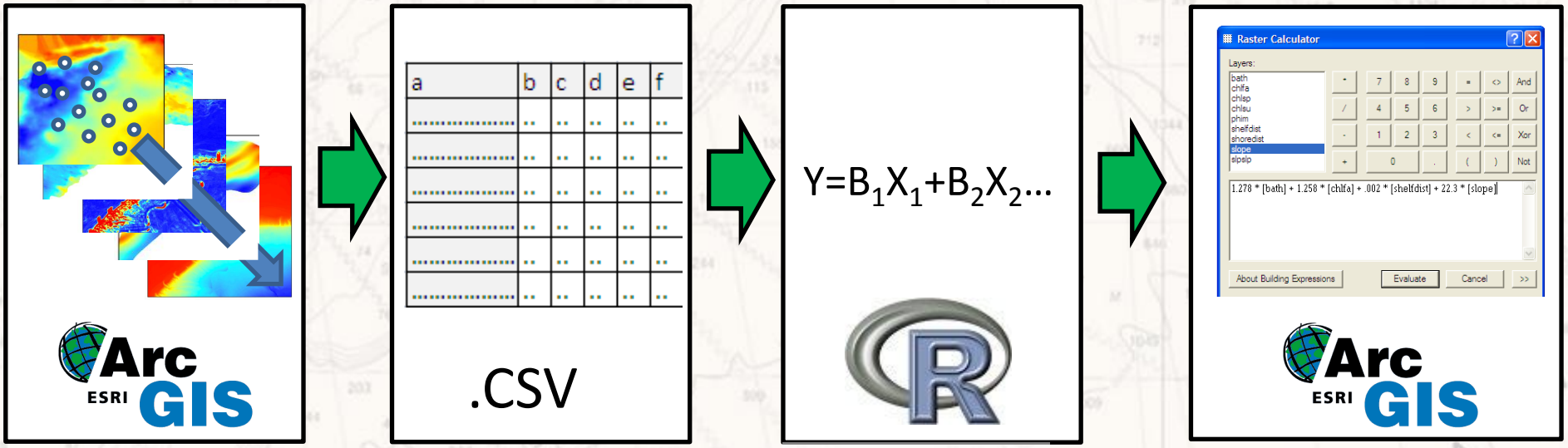
Data Exploration





- Approximate environmental relationships with **linear trend**
- Data is **extremely skewed** (lots of zeroes)
- Go with **Zero-Inflated Generalized Linear Models** (GLMs)

Workflow

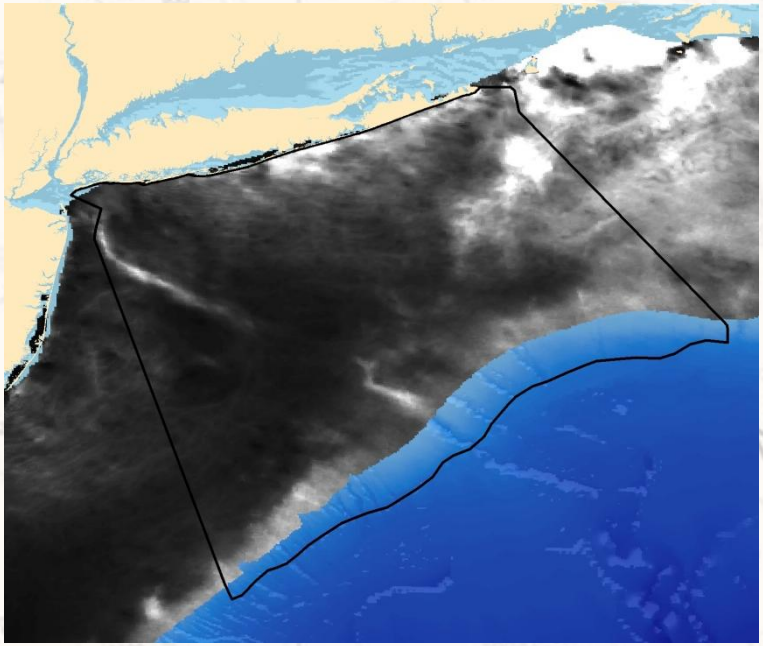


zeroinfl(),
Achim Zeileis

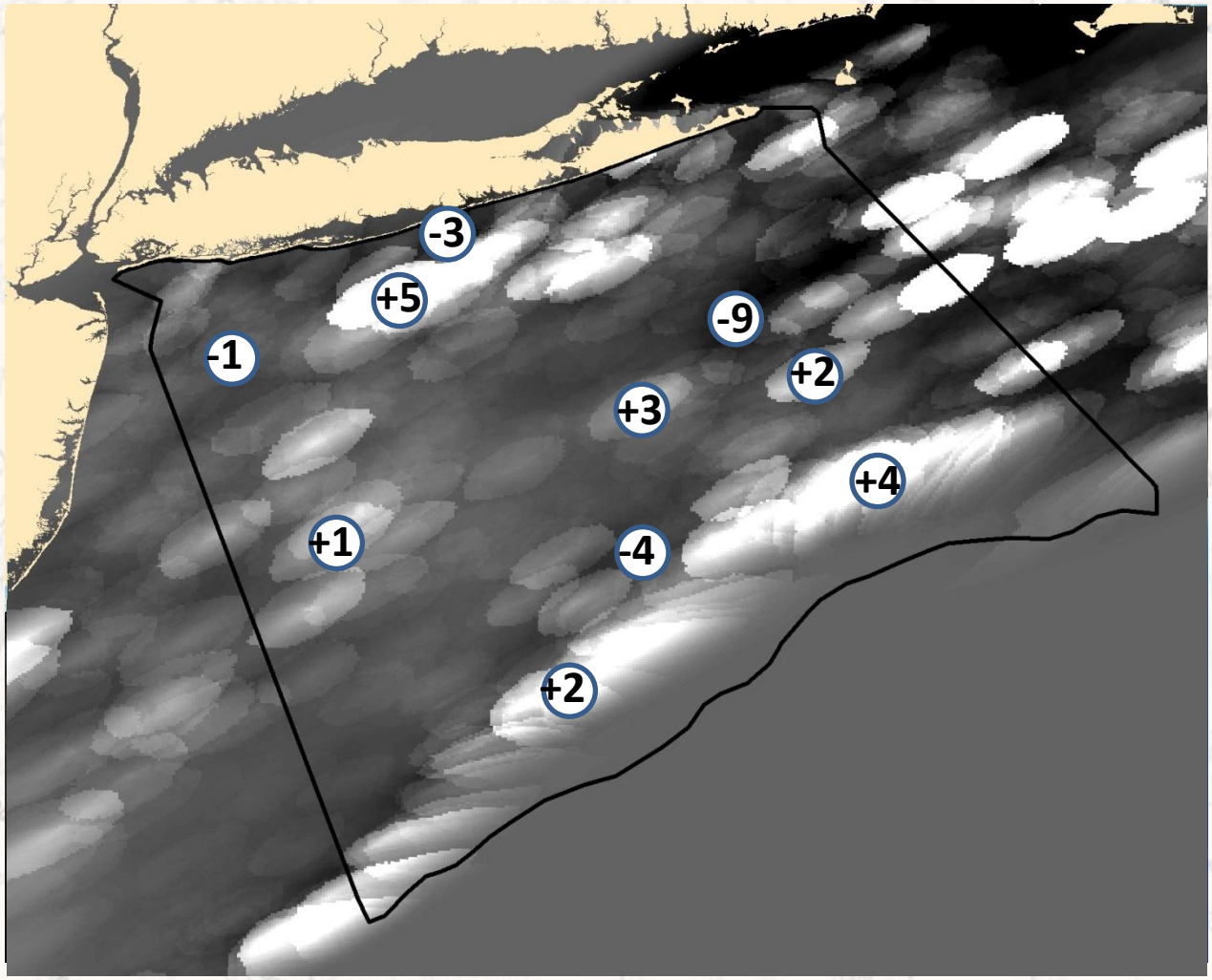
- "Loose" coupling
- With 10.x can "hard" couple via Geospatial Modeling Environment (GME)

Workflow

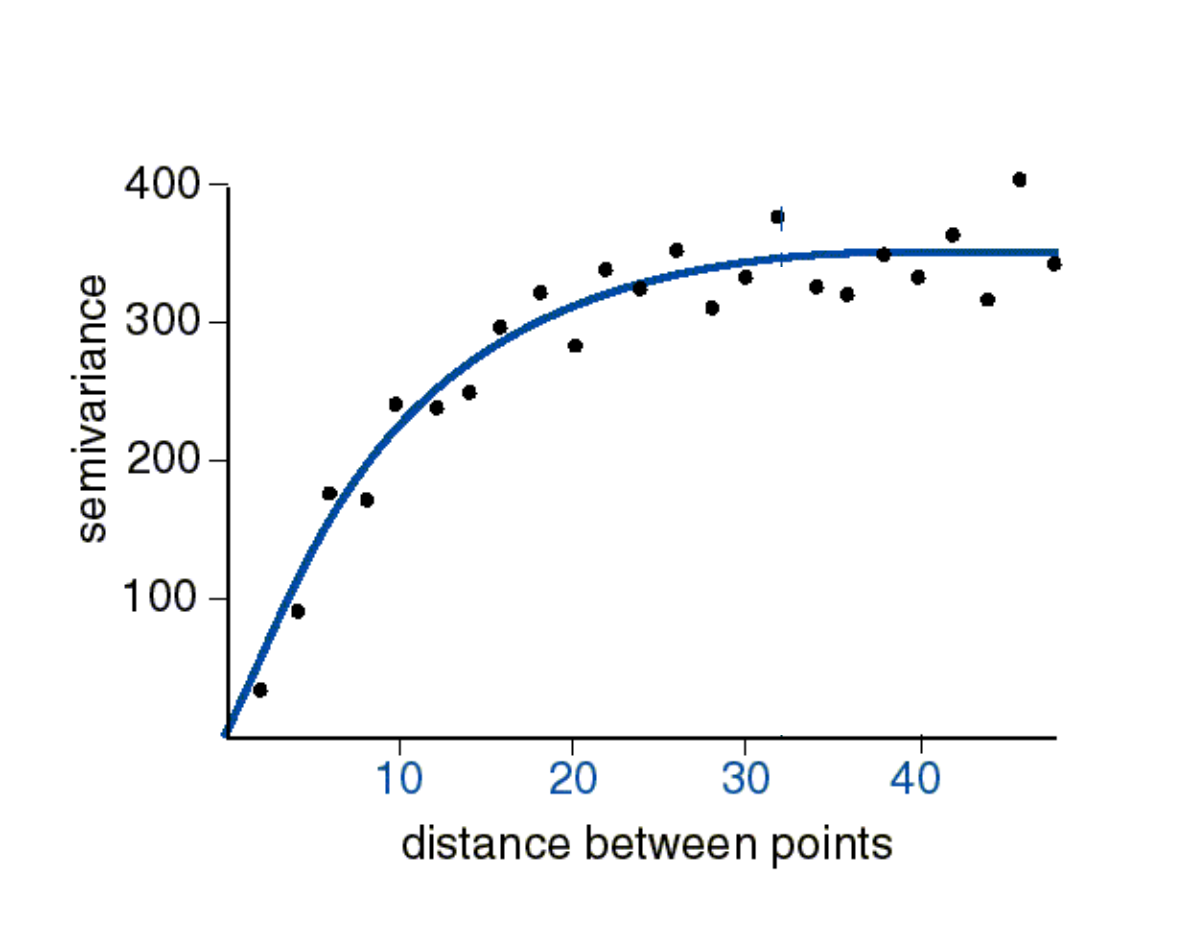
B_1 *  + B_2 *  + B_3 *  =



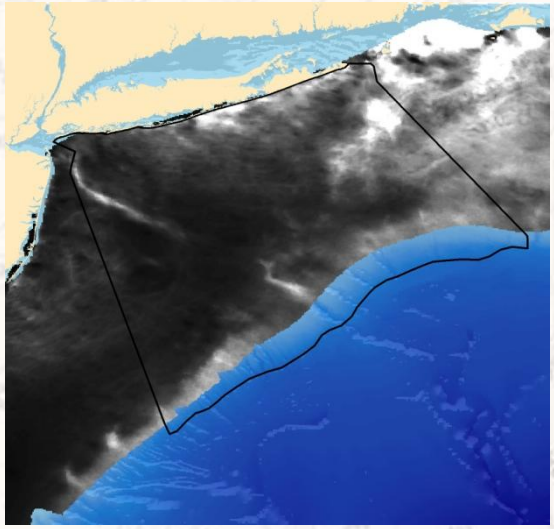
The Residual



Kriging Interpolation



Modeling Steps



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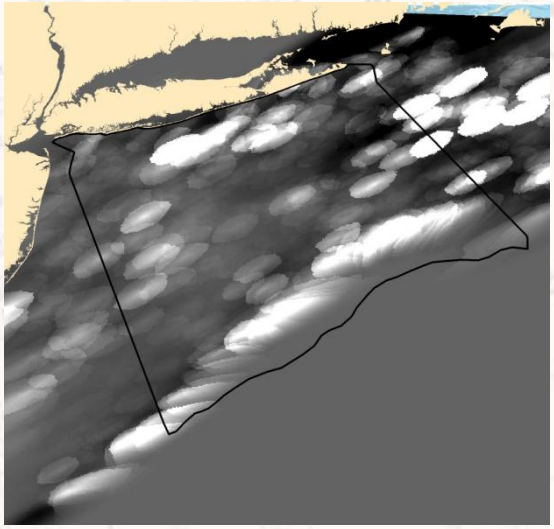

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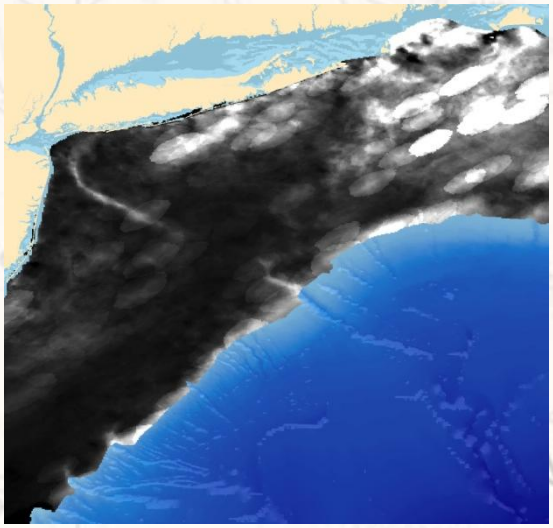
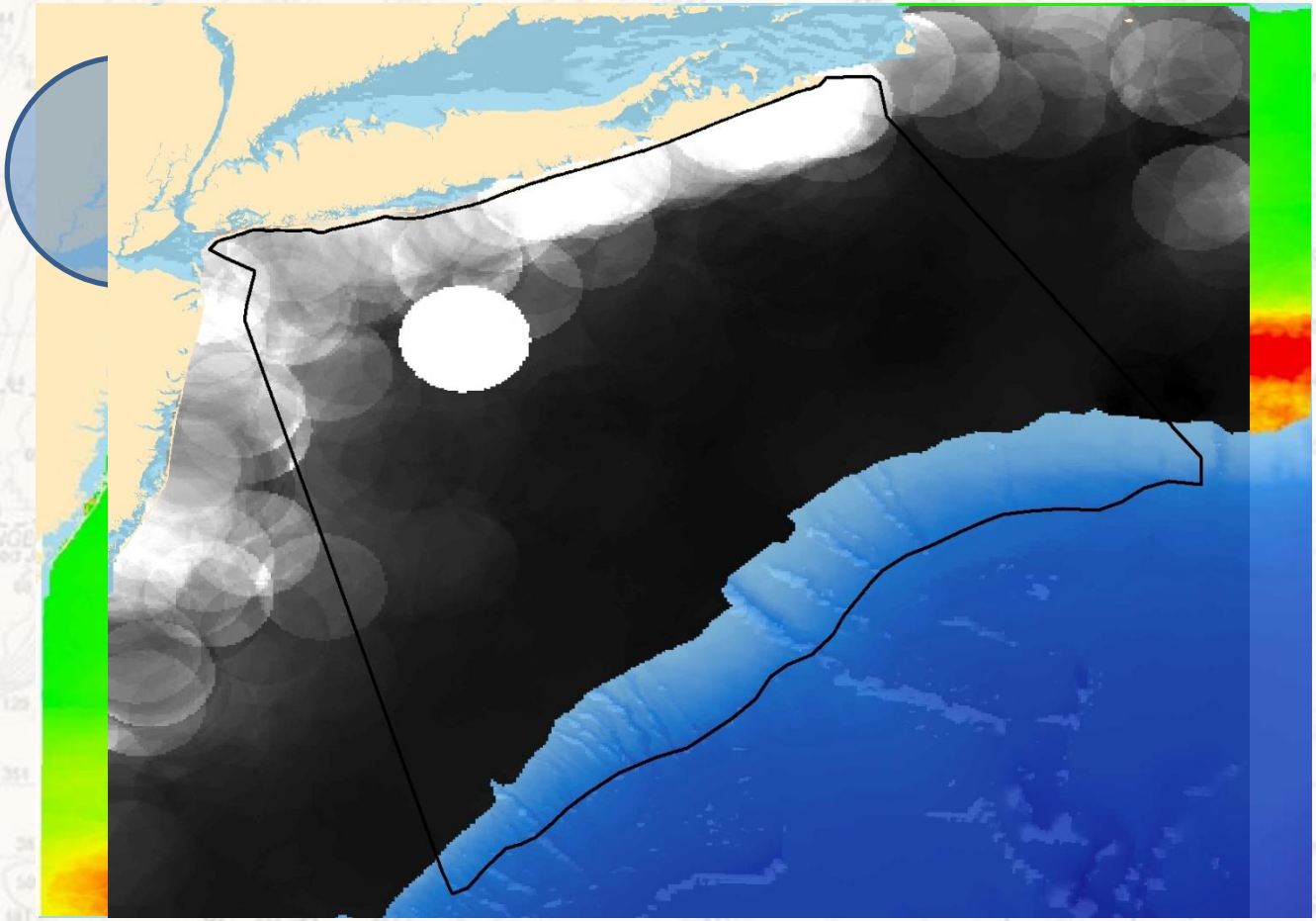


Predictors (GLM) **+** **Residual (kriging)** **=** **Mean Expectation**

+ Error
(unexplained variation)

Error Assessment

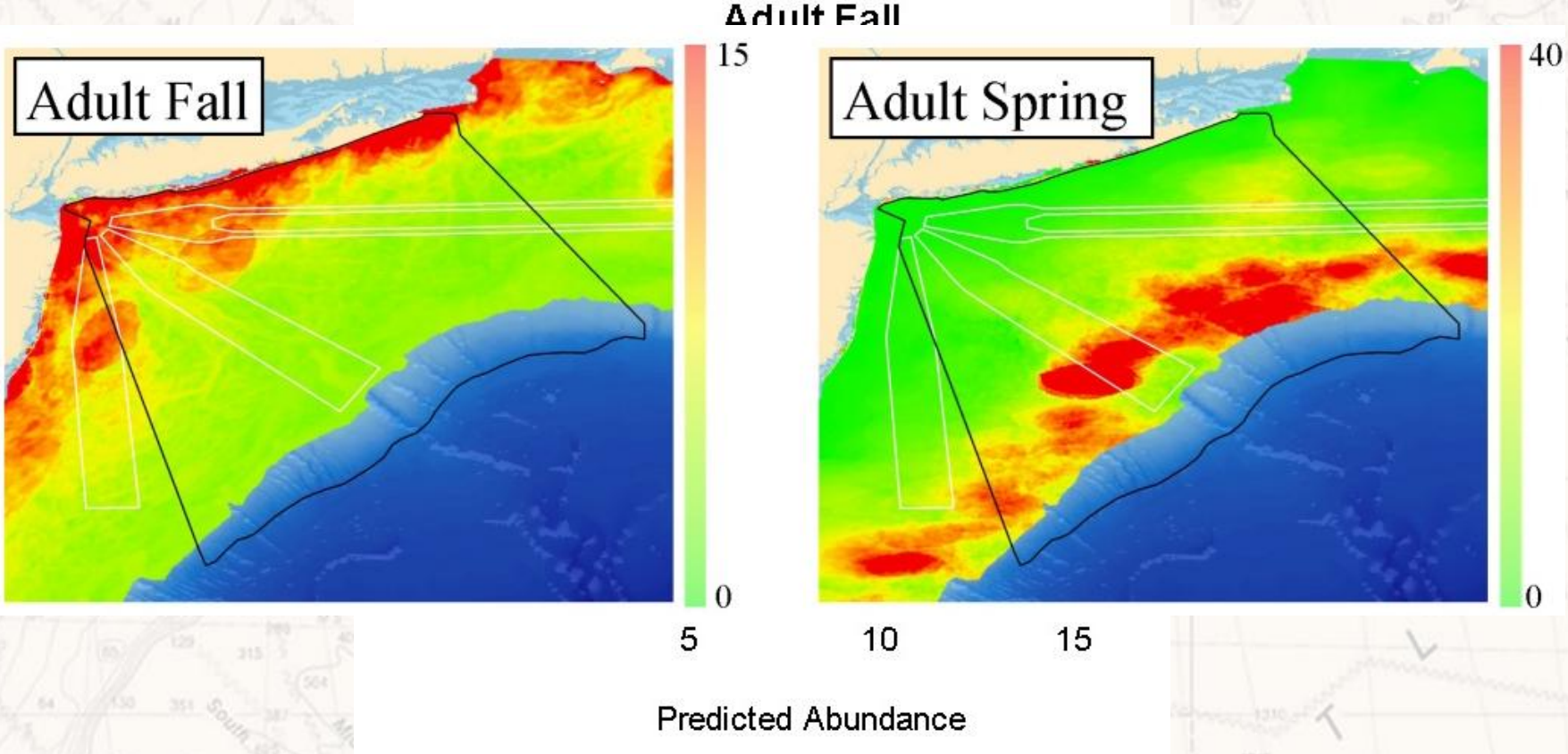


Error Assessment

- 50/50 **cross-validation**
- Smooth error with **moving window**
- **Final maps** based on **full dataset**
- **Conservative** error estimates

Final product

(fluke example)



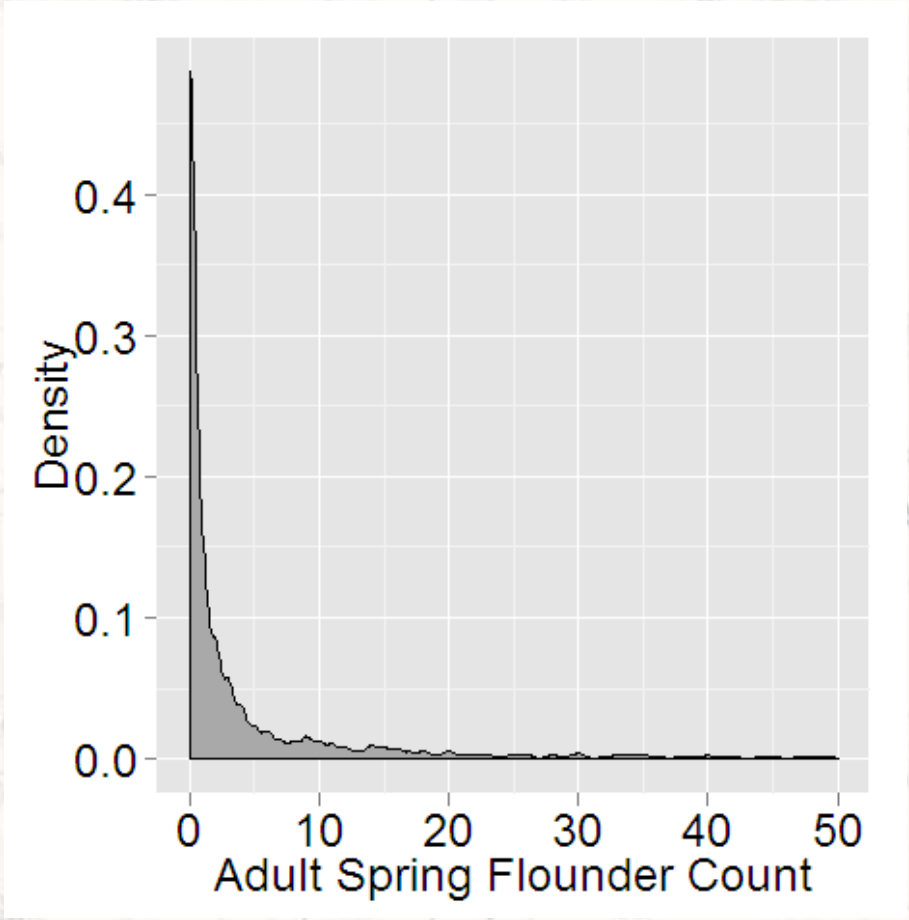
Goals

- **Predict the abundance** of selected groundfish **as a function of**:
  - **environmental**/habitat variables 
  - spatial **autocorrelation** 
- Assess **error** 
- **Understand** ecology 

Another Approach to Dealing with Zeroes

Another Approach

- Rather than a one-size-fits all model…
- … model **presence/absence** and **abundance** with **two separate stages**
- May **better reflect** ecological **reality**
- More **conservative** approach



Goals

- **Predict the abundance** of selected cetaceans **as a function of**:
  - spatial **autocorrelation**

- Assess **error**

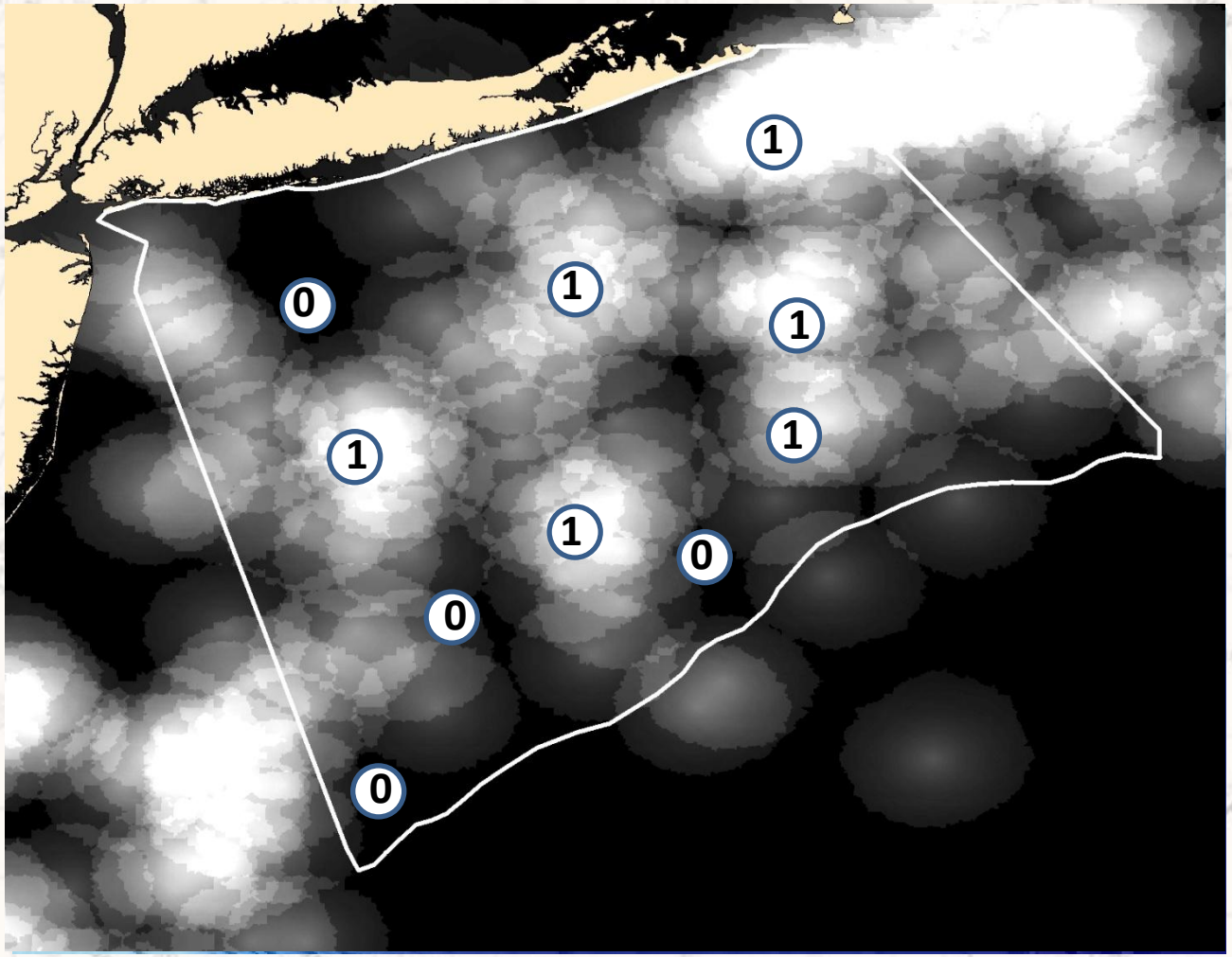
The Marine Mammal Data

- North Atlantic Right Whale Consortium Database
- Aerial and shipboard surveys, 1978 - 2009
- Cleaned by New England Aquarium
- **SPUE**
- 4 species/groups selected
- No predictors this time!

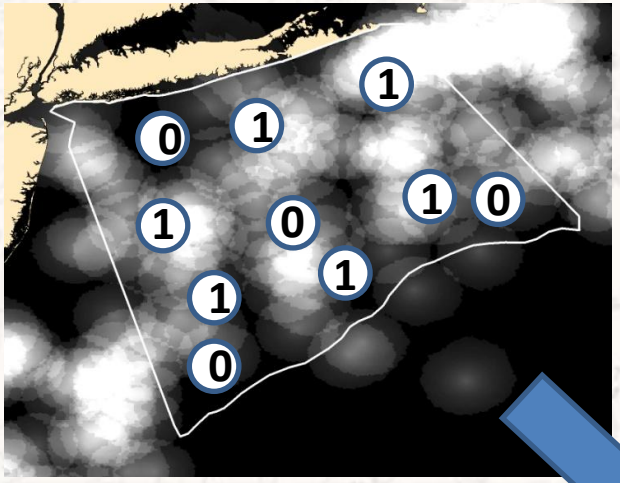
NOAA SWFSC

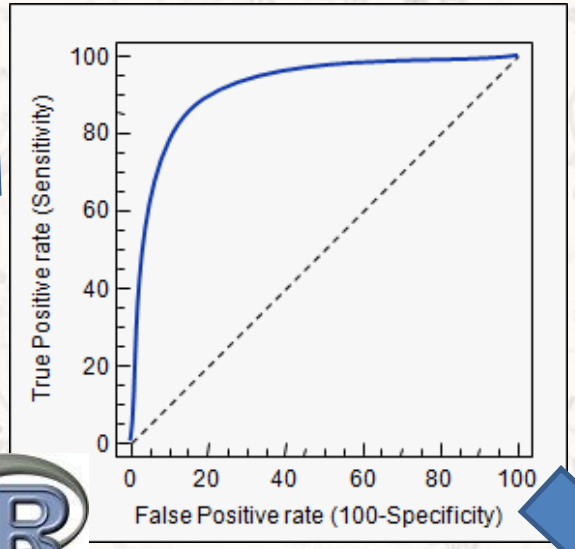

NOAA SWFSC

Stage I – Presence/Absence



Stage I – Presence/Absence

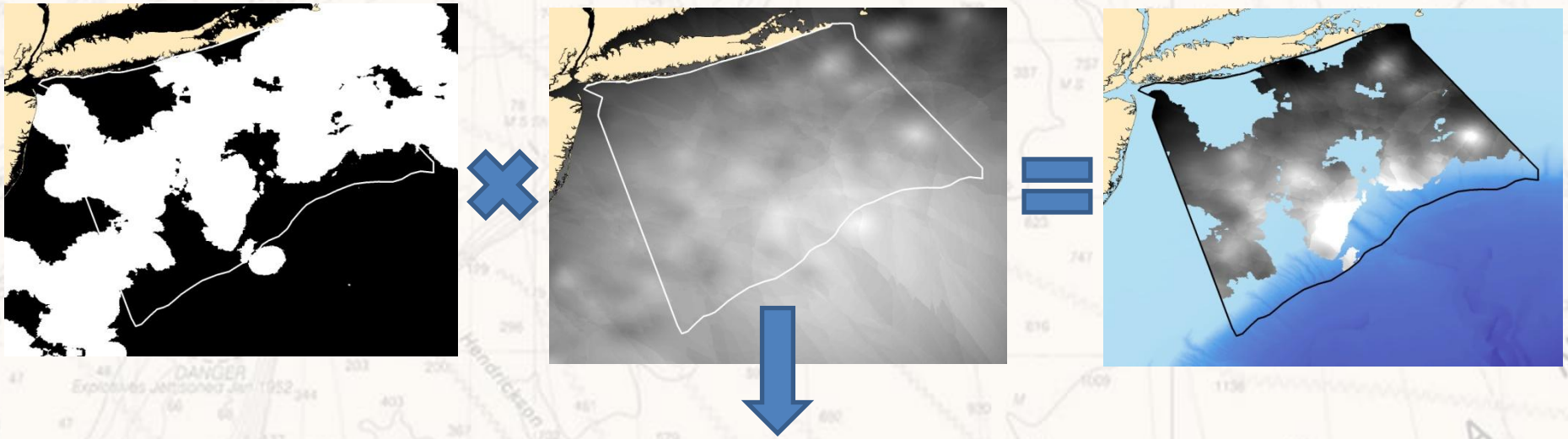


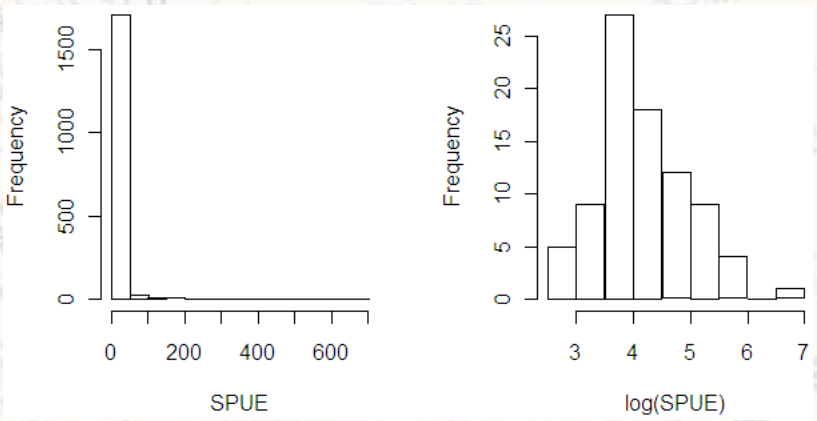


ROC Curve

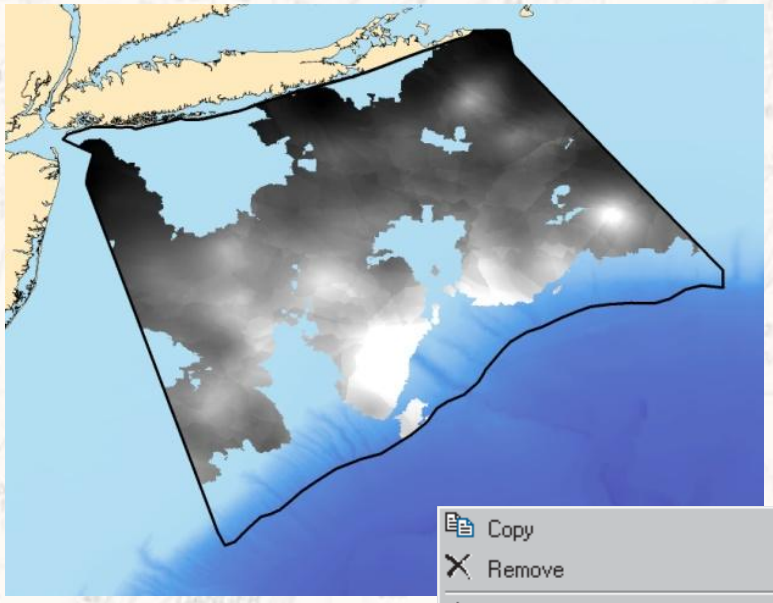
Epi package,
Carstensen et. al.

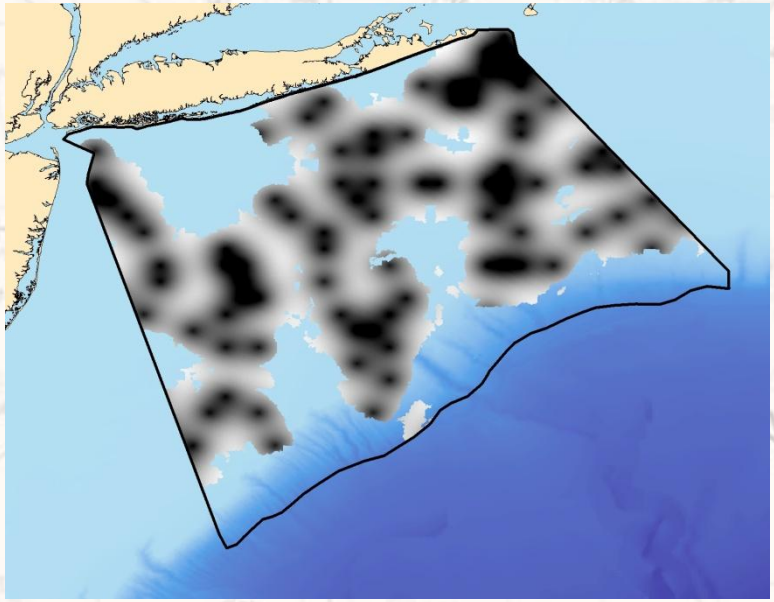
Stage I * II – Abundance Where Present

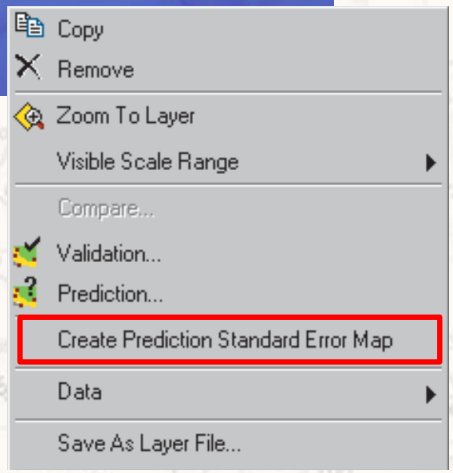




Error Assessment



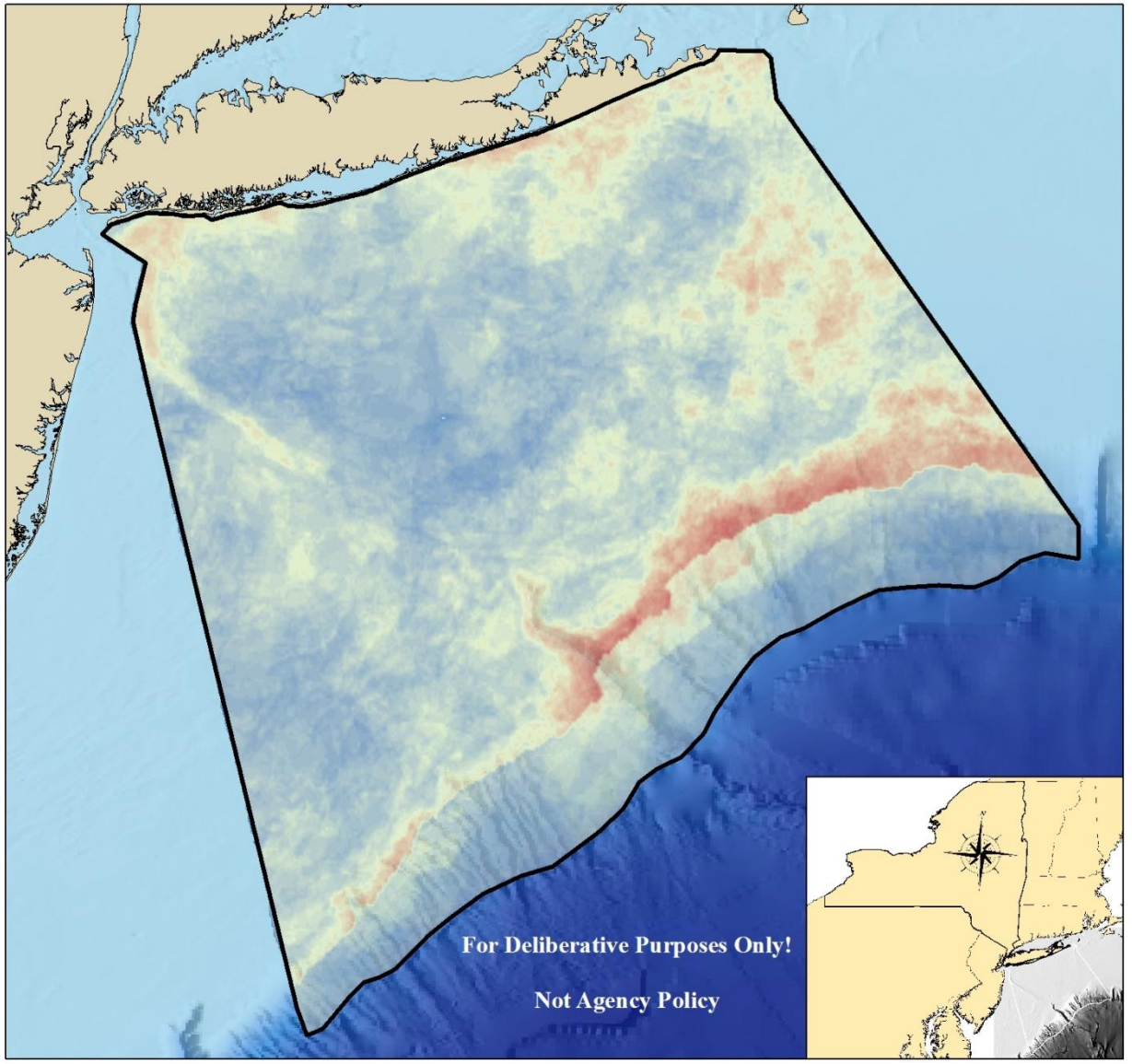




Goals

- **Predict the abundance** of selected cetaceans **as a function of**:
  - spatial **autocorrelation** 
- Assess **error** 

End goal



Further reading

- Hengl, T., G.B.M. Heuvelink and D.G. Rossiter. 2007. **About regression-kriging: From equations to case studies**. Computers and Geosciences 33:1301-1315.

- Wenger, S. J. and M. C. Freeman. 2008. **Estimating Species Occurrence, Abundance, And Detection Probability Using Zero-Inflated Distributions**. Ecology 89:2953-2959

- Monestiez, P., L. Dubroca, E. Bonnin, J.-P. Durbec, C. Guinet. 2006. **Geostatistical modeling of spatial distribution of *Balaenoptera physalus* in the Northwestern Mediterranean Sea from sparse count data and heterogeneous observation efforts**. Ecological Modeling, 193: 615-628

- Menza, C., B.P. Kinlan, D.S. Dorfman, M. Poti and C. Caldow (eds.). 2012**. A Biogeographic Assessment of Seabirds, Deep Sea Corals and Ocean Habitats of the New York Bight: Science to Support Offshore Spatial Planning**. NOAA Technical Memorandum NOS NCCOS 141. Silver Spring, MD. 224 pp.

Thank you!

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